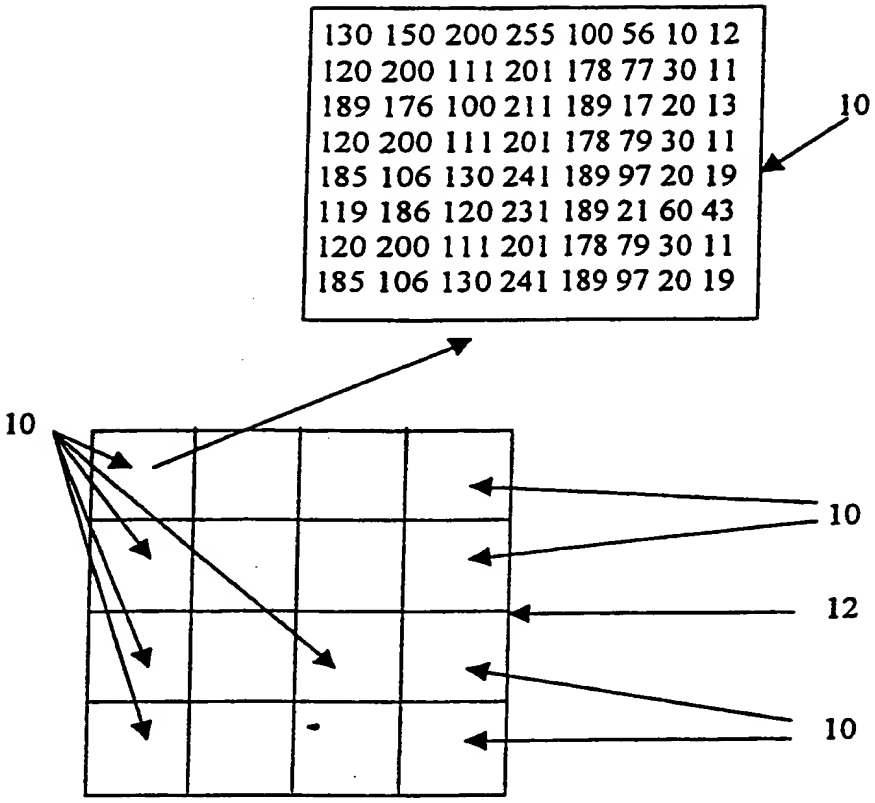


FIGURE 1

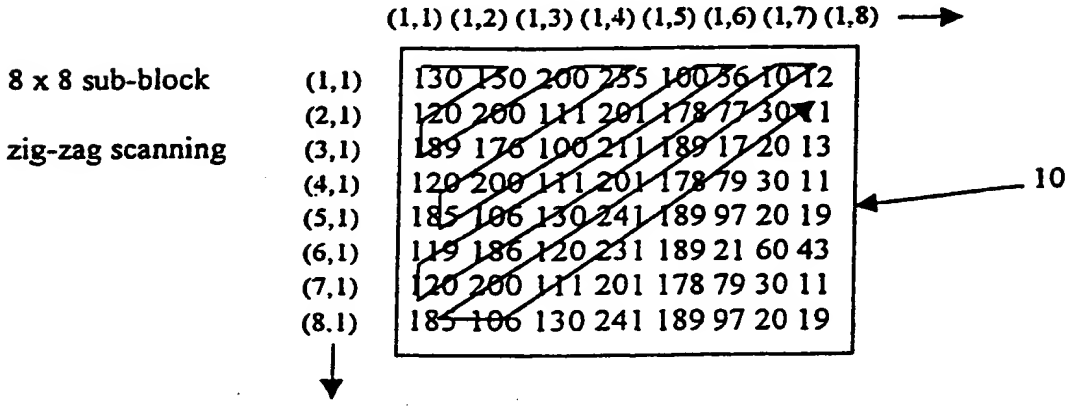
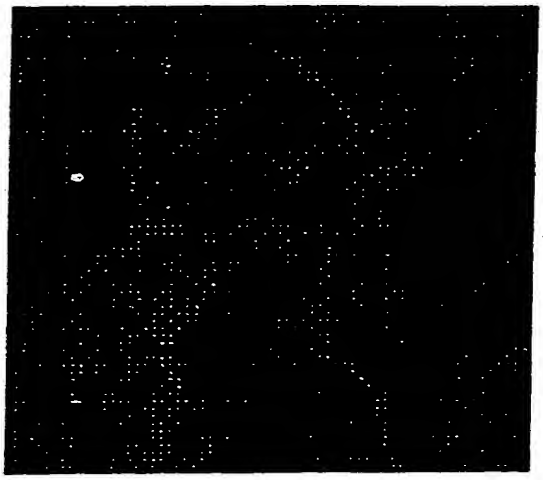


FIGURE 2

(a)



(b)

FIGURE 3

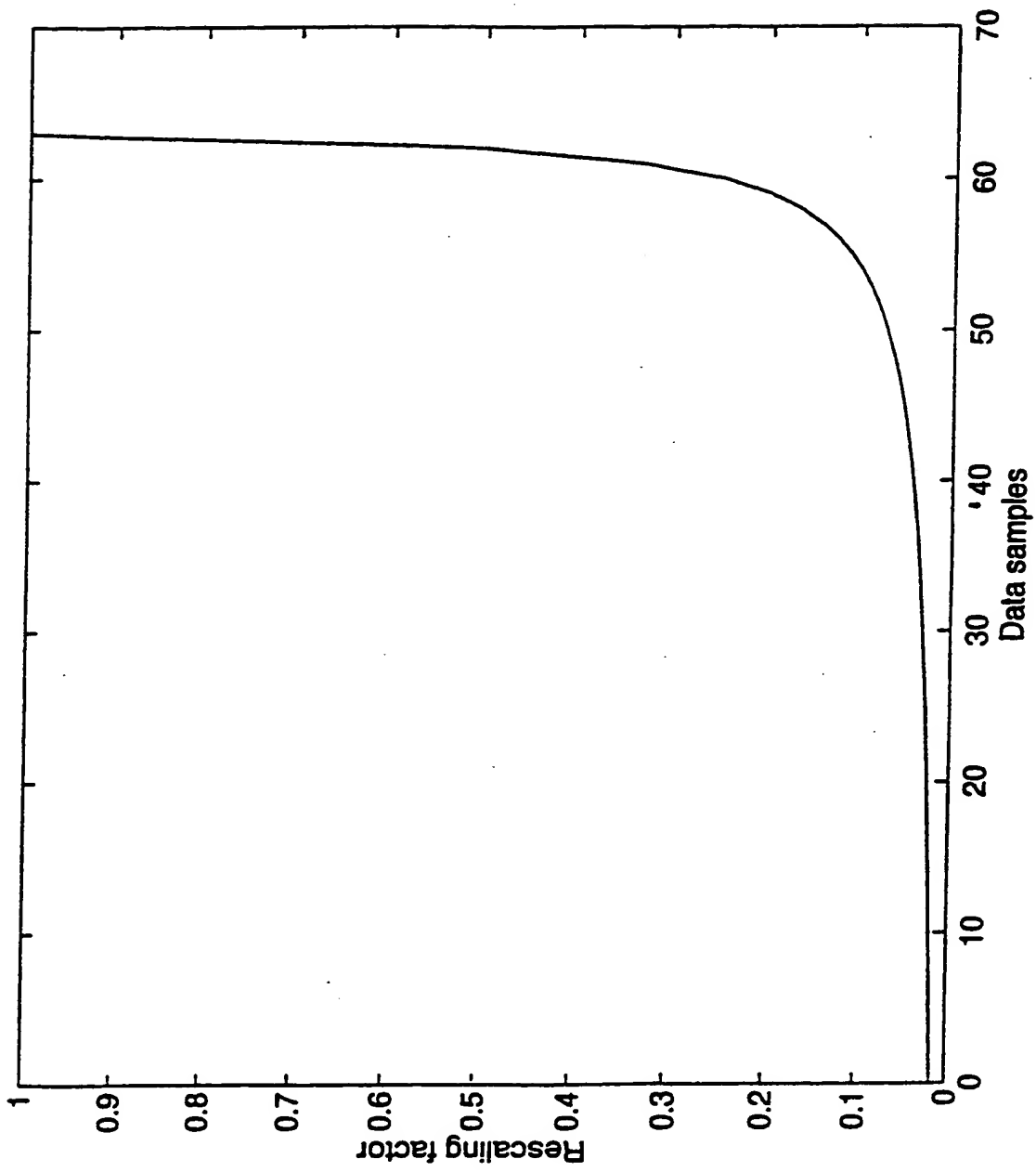

Rescaling factor
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
Data samples

FIGURE 4

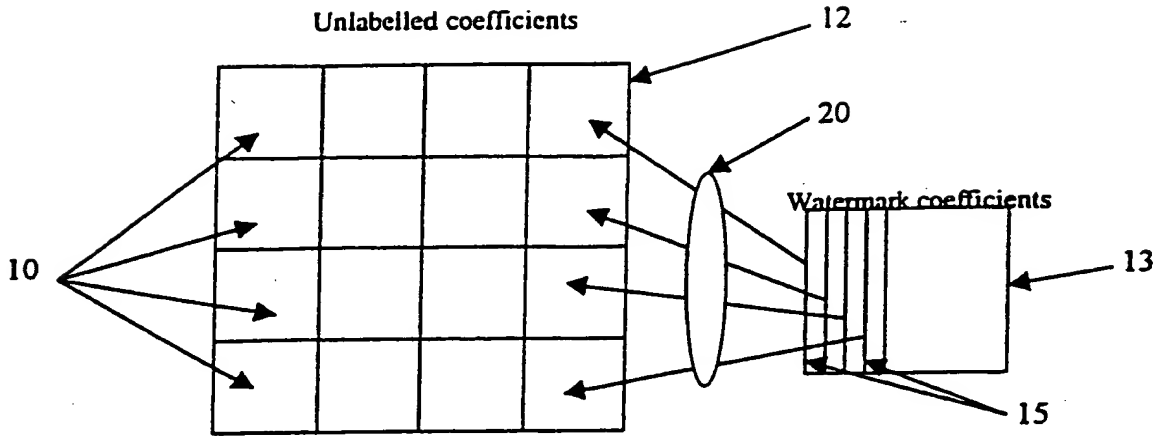


FIGURE 5

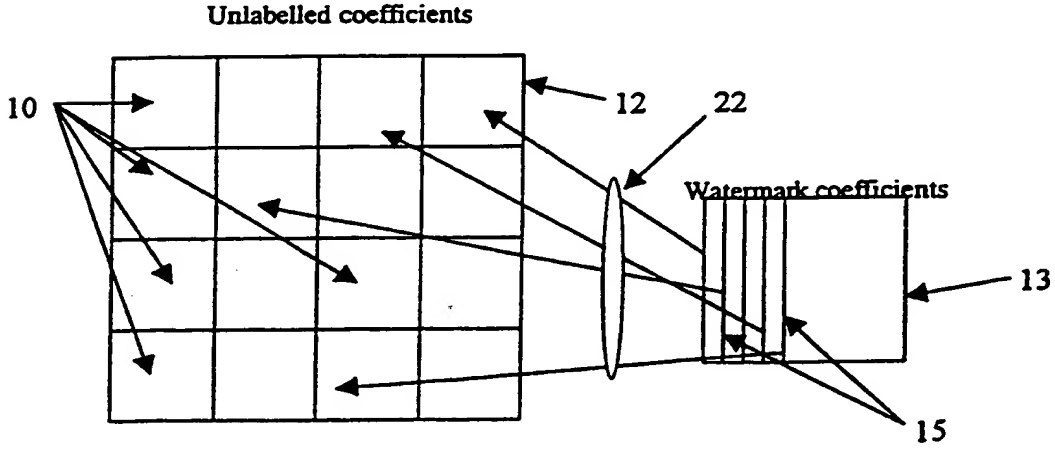


FIGURE 6

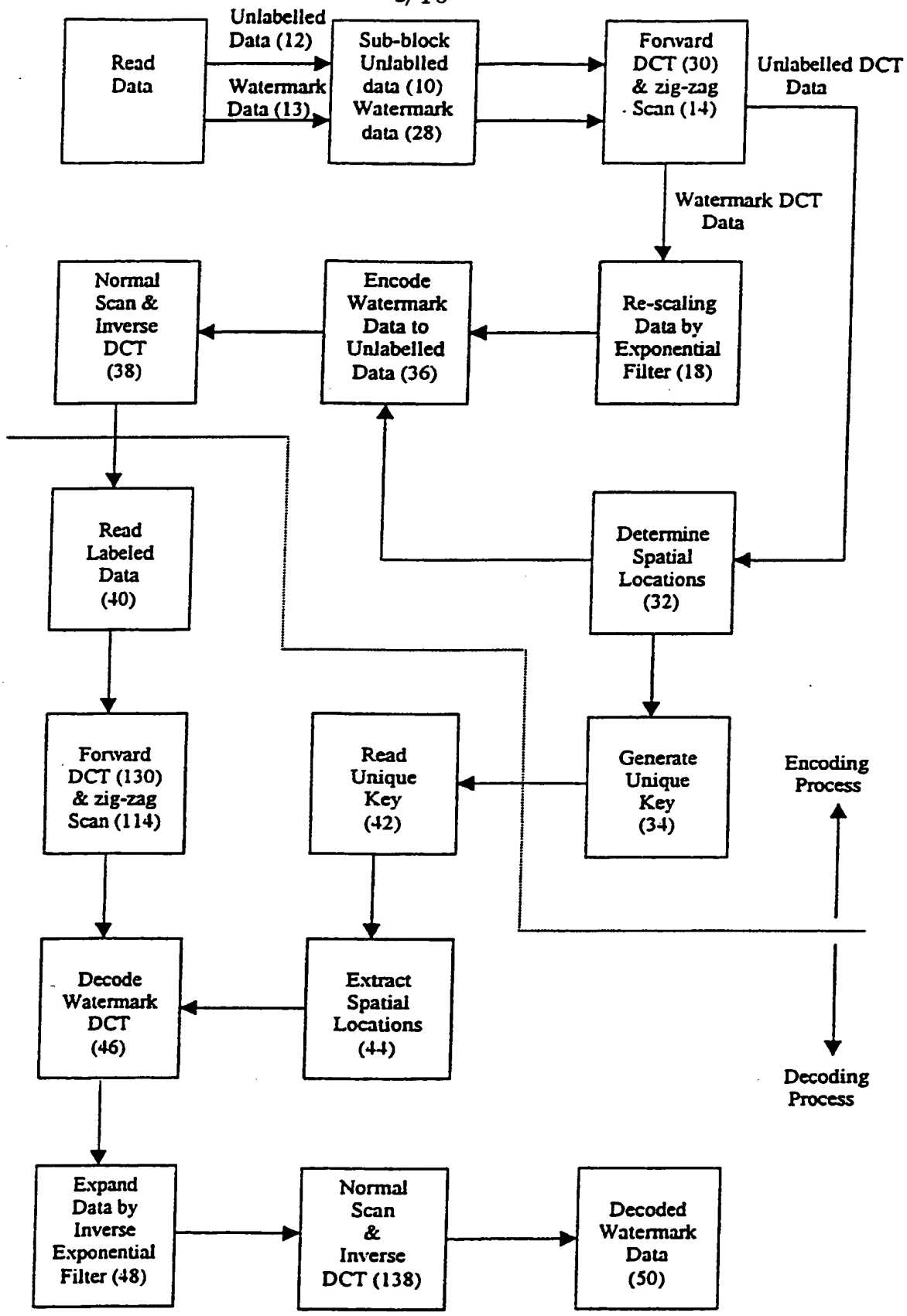

Read Data
Unlabelled Data (12)
Watermark Data (13)
Sub-block Unlabelled data (10) Watermark data (28)
Forward DCT (30) & zig-zag Scan (14)
Unlabelled DCT Data
Watermark DCT Data
Normal Scan & Inverse DCT (38)
Encode Watermark Data to Unlabelled Data (36)
Re-scaling Data by Exponential Filter (18)
Read Labeled Data (40)
Determine Spatial Locations (32)
Forward DCT (130) & zig-zag Scan (114)
Read Unique Key (42)
Generate Unique Key (34)
Encoding Process
Decode Watermark DCT (46)
Extract Spatial Locations (44)
Decoding Process
Expand Data by Inverse Exponential Filter (48)
Normal Scan & Inverse DCT (138)
Decoded Watermark Data (50)

FIGURE 7

```
*PSEUDOCODE*

PROCEDURE WATERMARK CODER

BEGIN
        READ UNLABELLED DATA;
        CONVERT UNLABELLED DATA TO MATRIX (M,N);
        PERFORM SUB-BLOCKING of UNLABELLED DATA;
        PERFORM DCT ON UNLABELLED DATA SUB-BLOCKS;
        RE-ORDER DCT COEFFICIENTS TO FOLLOW ZIG-ZAG PATTERN;
        DETERMINE AC ENERGIES OF DCT COEFFICIENTS;
        SET THRESHOLD BASED ON AC ENERGY MEAN AND STANDARD
        DEVIATION;
        COMPARE SUB-BLOCK AC ENERGIES WITH THRESHOLD;
        IF AC ENERGIES LESS THAN THRESHOLD THEN
                STORE SPATIAL LOCATIONS;
        ELSE
                SET TO OFFSET SPATIAL LOCATIONS;
        END
        GENERATE UNIQUE KEY FROM STRUCTURED/RANDOM SPATIAL
        LOCATIONS;
        STORE UNIQUE KEY FOR DECODING;

        READ WATERMARK DATA;
        CONVERT WATERMARK DATA TO MATRIX (J,K);
        PERFORM SUB-BLOCKING of WATERMARK DATA;
        PERFORM DCT ON UNLABELLED DATA SUB-BLOCKS;
        RE-ORDER DCT COEFFICIENTS TO FOLLOW ZIG-ZAG PATTERN;
        RE-SCALE DCT COEFFICIENTS USING EXPONENTIAL FILTER;

        EMBED RE-SCALED WATERMARK DCT COEFFICIENTS INTO
        UNLABELLED DCT SUB-BLOCKS;
        CONVERT ZIG-ZAG SCAN BACK TO NORMAL SCAN;
        INVERSE DCT SUB-BLOCKS TO OBTAIN LABELED DATA;
END
```

FIGURE 8a

```
*PSEUDOCODE*

PROCEDURE WATERMARK DECODER

BEGIN
        READ LABELED DATA;
        CONVERT LABELED DATA TO MATRIX (M,N);
        PERFORM SUB-BLOCKING of LABELED DATA;
        PERFORM DCT ON LABELED DATA SUB-BLOCKS;
        RE-ORDER DCT COEFFICIENTS TO FOLLOW ZIG-ZAG PATTERN;

        EXTRACT SPATIAL LOCATIONS FROM UNIQUE KEY;
        DECODE WATERMARK DCT COEFFICIENTS FROM SPATIAL
        LOCATIONS;
        SCALE WATERMARK DCT COEFFICIENTS USING INVERSE
        EXPONENTIAL FILTER;
        CONVERT ZIG-ZAG SCAN BACK TO NORMAL SCAN;
        INVERSE DCT SUB-BLOCKS TO OBTAIN WATERMARK DATA;
END
```

FIGURE 8b

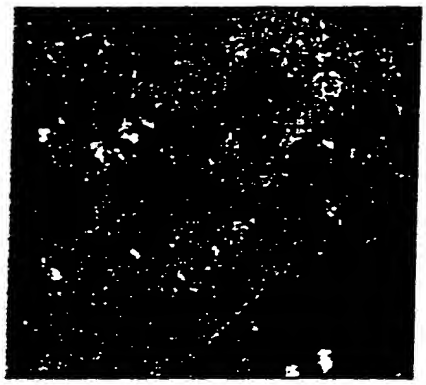
(a)

(b)

(a)

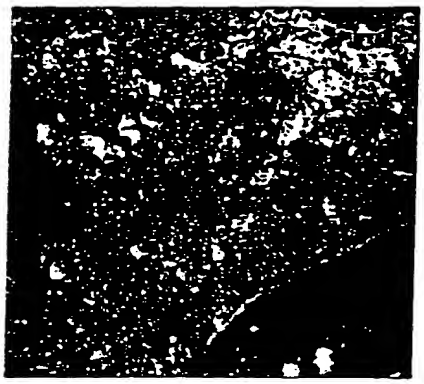
(b)

FIGURE 9



(a)

(b)



(a)

(b)

FIGURE 10

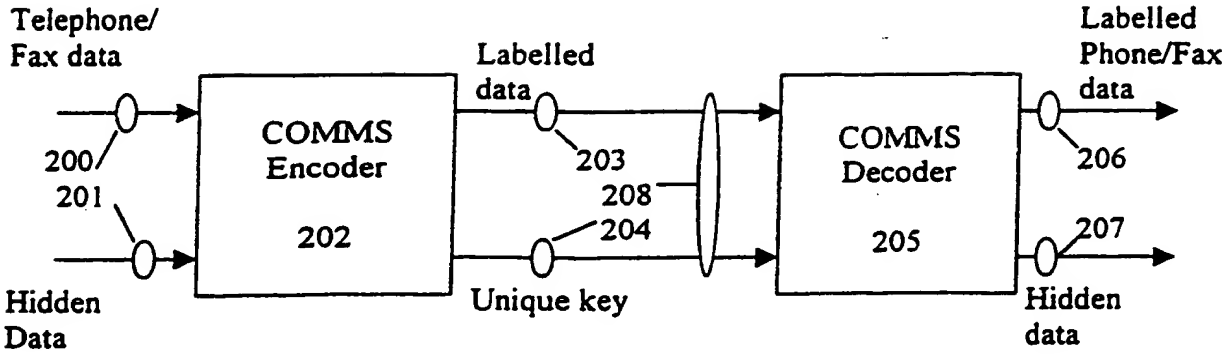


FIGURE 11

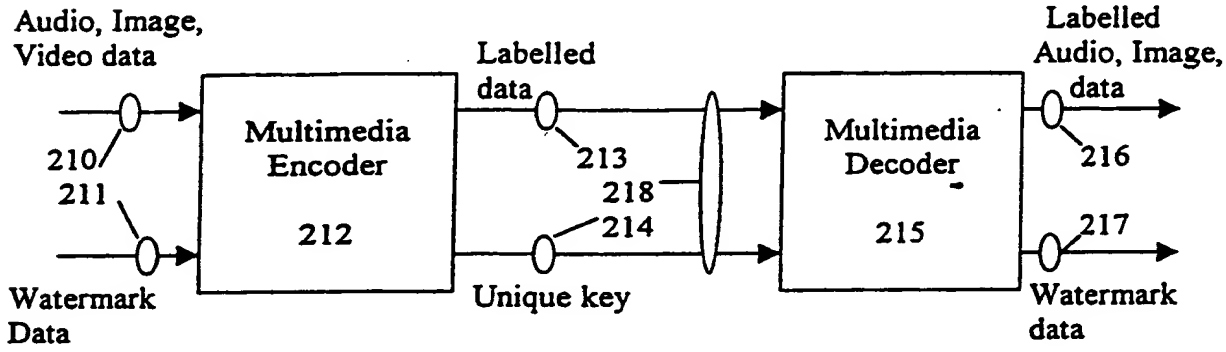


FIGURE 12

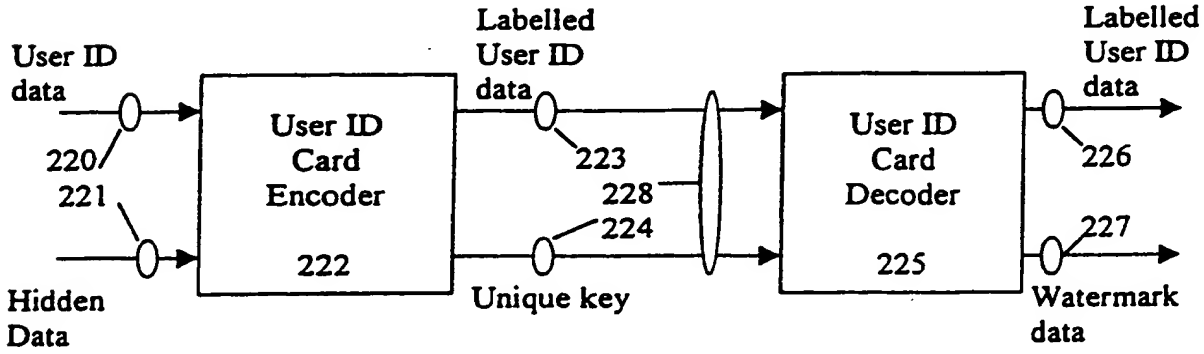


FIGURE 13